PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G05D 23/19 — A1

(11) International Publication Number: **WO 97/46928**

(43) International Publication Date: 11 December 1997 (11.12.97)

(21) International Application Number: PCT/IB97/00779

(22) International Filing Date: 3 June 1997 (03.06.97)

(30) Priority Data:

9611509.2	4 June 1996 (04.06.96)	GB
9611626.4	4 June 1996 (04.06.96)	GB

(71) Applicant *(for all designated States except US)*: PHET IRELAND LIMITED [IE/IE]; 44 Hebron Industrial Estate, Kilkenny (IE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: DUNNE, James, Patrick [IE/IE]; Newpark Lawn, Kilkenny (IE).

(74) Agents: QUEST, Barry et al.; Wilson Gunn M'Caw, 41-51 Royal Exchange, Cross Street, Manchester M2 7BD (GB).

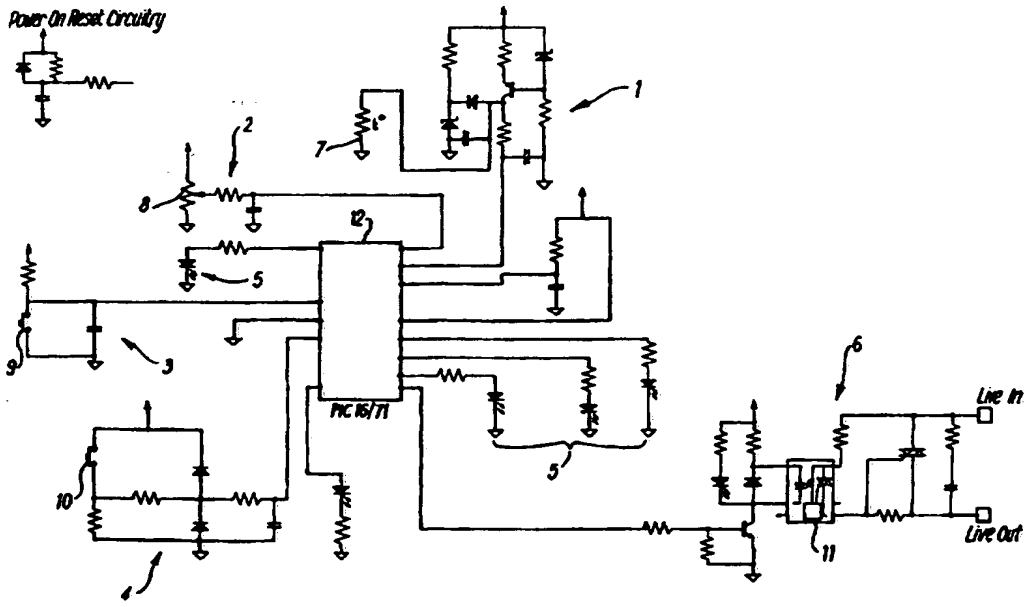
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: CONTROL SYSTEM FOR ELECTRICAL HEATING EQUIPMENT



(57) Abstract

A control system for electrical heating equipment has a thermal parameter sensor, such as a temperature sensor (7), a control processor (12), and a power output control circuit (6) which uses triac devices (11). The system can control heating of water or food or other fluid or solid materials.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

CONTROL SYSTEM FOR ELECTRICAL HEATING EQUIPMENT

This invention relates to a control system for electrical heating equipment. The invention can be used for the temperature control of fluids and more particularly the temperature control of liquids especially water. However, the invention may also be used in cooking to control heating of solids such as food or for other purposes, e.g. for industrial materials.

The temperature control of fluids has been accomplished in many ways. Usually a temperature sensor is provided which controls a heater so that the heater is switched off when the fluid temperature reaches, or exceeds, a predetermined level and/or switched on when the fluid temperature drops to, or below, a predetermined temperature. If the temperature of a fluid flow is to be controlled as is the case with a shower it is frequently necessary to monitor the rate of fluid flow as well as the temperature.

One particular form of temperature control used in kettles and the like for boiling water comprises means for sensing the presence of steam which in turn controls the heating means.

According to one aspect of the invention there is provided a control system for electrical heating equipment for heating a medium, comprising an electrical power supply switching circuit, a sensor for monitoring a

thermal parameter of the medium, and a control device for controlling the switching circuit in relation to said thermal parameter as sensed with the sensor, wherein the control device comprises programmable processing means, and the switching circuit has power output control properties.

According to a second aspect of the invention there is provided an apparatus for controlling the temperature of a fluid comprising an electric heating element disposed on a stainless steel or ceramic substrate and a temperature sensor printed on said substrate, means responsive to the sensor for monitoring the change of temperature of the fluid with respect to time and means controlled by the monitoring means for controlling the operation of the heating element.

With the second aspect of the invention, monitoring the rate of change of temperature can be used to indicate that a liquid is boiling since in that condition there is no temperature change. Other parameters can also be controlled by monitoring the rate of change of temperature. For example if the rate of change is very fast it is an indication that there is no liquid or fluid present to be heated. This condition can be used to cut off power to the heater element.

The invention also enables a heater to be disabled when the temperature of a liquid heated by the heater element reaches a predetermined temperature below boiling. For example in the preparation

of coffee using so called "instant coffee" it is not necessary to use boiling water and water at 80°C for example is satisfactory, particularly for vending machines and the like.

The control of cooking of food items is often required for items which change colour upon heating such as the toasting of bread.

The control of toasting of bread in toasting devices is conventionally by time. However, this is a somewhat hit and miss method. New bread takes longer to toast to a particular shade of brown than does rather older bread, for example. It is now quite common practice to store bread in a frozen condition and then to make toast using frozen slices of bread. A toaster set to toast by time only will often only unfreeze a frozen slice of bread rather than produce good looking toast.

According to a third aspect of the invention there is provided a device for controlling the cooking of food items which change colour upon heating, comprising means for directing radiation at the food item while it is being cooked and receiving means for detecting the level of radiation reflected from the food item, said receiving means being adapted to stop the cooking process when the reflected radiation reaches a predetermined level.

In a preferred embodiment of the third aspect of the invention the radiation is infra red radiation and the receiving means is an infra red receiver. The receiver can be set to disable the power supply to the cooker

when the radiation reflected from the food item reaches a preset level. Preferably a plurality of receivers is provided so that the reflected radiation from a plurality of sites over the food item being cooked can be monitored.

The third aspect of the invention is particularly applicable to making toast from bread. The invention enables toast of a desired level of browning to be obtained irrespective of the condition of the bread.

The third aspect of the invention can be used in connection with toasters or other forms of cooker for institutional and domestic use. Preferably the heaters for the toaster comprise heating elements disposed on stainless steel substrates. The heaters may contain means for sensing the temperature thereof which can be used for further control. In addition means may be provided for keeping the toasted product warm at least for a period of time after toasting has been completed. The mode of the device, i.e. on, off, toasting, and so on can be indicated by audio and/or visual means such as an LED and/or audio alarm.

The invention will now be described further by way of example only and with reference to the accompanying drawing which is a circuit diagram of one form of a control system according to the invention.

The control system comprises a microprocessor 12 connected to input and output circuits.

The input circuits include:

a temperature sensor circuit 1, a temperature setting circuit 2, and reset and interrupt circuits 3, 4.

The output circuits include:

multiple lamp signalling circuits 5, and a power drive circuit 6.

Referring now in more detail to the input circuits, the temperature sensor circuit 1 includes a temperature sensitive element 7, in this case a thermistor.

The temperature setting circuit 2 includes a potentiometer control 8.

The reset and interrupt circuits 3, 4 have press buttons 9, 10.

Referring now to the output circuits, the lamp signalling circuits 5 comprise LEDs.

The power drive circuit 6 has live power supply input and output connections with triac circuitry 11 therebetween.

In use, the circuitry described can be connected to a kettle or domestic shower or some other equipment which requires temperature control. In this case, the thermistor 7 is exposed to the water in the kettle or other medium for which the temperature is to be monitored, and a heating element is connected to the output of the power drive circuitry 6.

The system is switched on and a desired temperature can be selected using the potentiometer 8.

The power drive circuit 6 is switched on and electric current flows to,

and operates the heating element. When the desired temperature is reached, as selected with the potentiometer 8 and as detected with the sensor 7, the current is switched off.

The microprocessor is pre-programmed in correspondence with requirements whereby power output from the power drive circuit 6 can vary.

Thus, in the case where fast boiling of water is required, the power drive circuit may produce maximum power output. In the case where slower heating of water to a temperature lower than boiling is required a lower level of power output may be appropriate. Also, where continued heating for a period after attainment of a temperature is required, e.g. to maintain water at boiling level, or at a constant temperature less than boiling, this may be achieved with a reduced level of power output.

Power output is selected by utilisation of 'firing angle' of the triac devices 11 in conventional manner.

There may be provision for preselection of a desired program with regard to power output levels, using input controls in conjunction with an LCD display or otherwise (not shown). Alternatively or additionally, this may be achieved automatically in correspondence with selection of a predetermined temperature. Other programs may also be selectable, relating to temperature, timing or other parameters or combinations. The LEDs 5

indicate operational status of the system.

With this embodiment, it will be appreciated that precise control of temperature and heating is possible having regard to the use of microprocessor and triac circuitry. Thus, for example, it is possible to use the system with a kettle to select a temperature less than boiling point (e.g. 86°-88°C) for coffee, or boiling point for tea.

The use of triac switching circuitry ensures careful control without generating undue interference problems. Careful control of switching and power is possible whereby this is particularly suitable for controlling heating of fluid flow as is the case with a domestic shower. It can be ensured that the fluid is maintained at a constant or desired temperature in relation to the rate of flow. Triac switching also assists in maintaining a prolonged temperature e.g. in cooking pans or the like.

The use of microprocessor circuitry also permits incorporation of other parameters into the control system either derived from external sensors or from internal programming. Thus, for example, there may be additional sensors which respond to level of water or steam temperature, so as to switch off power if the level of water in a kettle falls below a predetermined level.

The system can be used in cooking in combination with an input from a sensor which receives reflected radiation e.g. infra red radiation from toast

in a toaster so that the power can be switched off when the toast reaches a predetermined colouration.

The system can receive flow level input, so that power output is varied with variation in flow.

The system may also monitor passage of time to determine, for example, whether heating is proceeding at a desired rate so that the power output can be adjusted accordingly to attain a desired rate.

Due to the design of the circuit described the heat can be controlled by proportional control at zero crossing thus eliminating interference on all other circuits. This facility enables the user to apply the heat at only half of the time the element is switched on or one third or one quarter or whatever proportion of the time that you choose to achieve the function required. This is a good facility to use in the heating of water or liquids in water heaters, showers, electric kettles and other liquid or food heaters when a different range of temperatures are required to complete the necessary cycle. This can be useful in toasters and sandwich makers, skillets, rice pans, deep fat fryers, cooker tops and other cooking utensils where heat control is essential for to get the correct cooking temperature.

The system provides for water temperature sensing and verification in the case of hot and cold supplies. The controls built into the control circuits would include this facility. This would be particularly useful in the

case of a water heater or shower to enable the heater to take in either the hot or cold water depending on the time of year or demands etc.

The circuits can sense the water or liquid level in any vessel to be heated and will not allow any power to be switched on if there is no water/liquid in the vessel.

A range of temperatures can be selected to enable the user to preselect a desired temperature. This facility can be useful in the case of showers where you may require the temperature to be at 40° or say 42°. In a kettle or coffee maker one could select 100° or boiling point to make tea or 86/88° to make coffee as required. In more sophisticated heating devices for industrial use one could preselect the temperature required which would be shown on an LCD display. A flashing indicating LED would display or an alarm sounder would indicate as soon as the preset required temperature was reached.

The facility is included in the circuitry to enable the user to control the water supply rate to the shower or water heater as required. This is a useful facility in the case of a water shower heater where the rate of heat being applied to the water passing through the shower is constant and one wants to vary the temperature of the water by speeding up or slowing down the rate of flow of the water. The quicker the water flow the cooler the water and vice versa the slower the water flow the more the water heats

up.

The control circuits and sensors enables the user to sense and control the temperature of water to +/- 1°C. This is a very fine tolerance that has many applications in domestic appliances and water heaters/showers etc. where fine temperature control has not been available up to this point in time.

The control circuitry will enable the user to display on LCD the temperature of the water/liquid being heated at the moment it is switched on until it has completed its cycle. The LCD can be preset to any given temperature if required to be.

Alarm indicators can be included in the controls as indicators or warning devices to tell the user at what state the process is at. These can take the form of LED display light as visual display or an audio sounder to indicate the process is complete. This facility can be used on water/liquid heaters, kettles and coffee makers to indicate that the process is complete or the kettle has boiled.

Auto diagnostics of sensing probes is a standard feature which enables the circuits to decide whether or not to switch on the power to the elements. This facility is essential in water/liquid heaters as it is a very good safeguard which prevents possible fire and or fire or smoke damage in houses and business premises when water/liquid heaters are left switched

on without any water/liquid in the vessel to be heated.

The circuitry will facilitate zero crossing control of all on/off switching operations. This has the benefit of eliminating interference on all other circuits in the house/premises and facilitates the long lasting of the controls in all electrical products as the contacts will be under less demand when switched closed or open circuit.

A remote operation status of control unit could be used using an RF data link.

FEATURES WHICH CAN BE MADE AVAILABLE ON THE ABOVE CONTROL CIRCUITS ARE AS FOLLOWS:

SHOWER HEAT SELECTION SWITCH. HIGH MEDIUM OR LOW.

WATER FLOW CONTROL RATE IN SHOWER THROUGH CONTROL OF PUMP SPEED.

KETTLE SELECTION SWITCH FOR TEA 100°C OR COFFEE 86°C.

AT TEMPERATURE VISUAL OR AUDIBLE WARNING FACILITY.

WATER LEVEL PROBE SENSING TO ENSURE NO HEAT IS APPLIED IF NO WATER PRESENT.

THREE TRIAC DRIVE CIRCUITS.

PRESET TEMPERATURE CONTROLS ON THE SOFTWARE FOR TEA/COFFEE MAKER.

POTENTIOMETER CONTROLLER FOR SHOWER TEMPERATURE.

SOFTWARE DIAGNOSTIC ROUTINE TO MONITOR SENSORS AND INDICATORS.

It is of course to be understood that the invention is not intended to be restricted to the details of the above embodiment which are described by way of example only.

CLAIMS

1. A control system for electrical heating equipment for heating a medium, comprising an electrical power supply switching circuit, a sensor for monitoring a thermal parameter of the medium, and a control device for controlling the switching circuit in relation to said thermal parameter as sensed with the sensor, wherein the control device comprises programmable processing means, and the switching circuit has power output control properties.

2. A system according to claim 1 wherein the sensor comprises a temperature sensor.

3. A system according to claim 1 or 2 including an input device connected to the processor for preselection of a desired temperature to be attained with the heating equipment.

4. A system according to any one of claims 1 to 3 wherein the switching circuit comprises a triac circuit.

5. A system according to any one of claims 1 to 4 further including a fluid flow sensor.

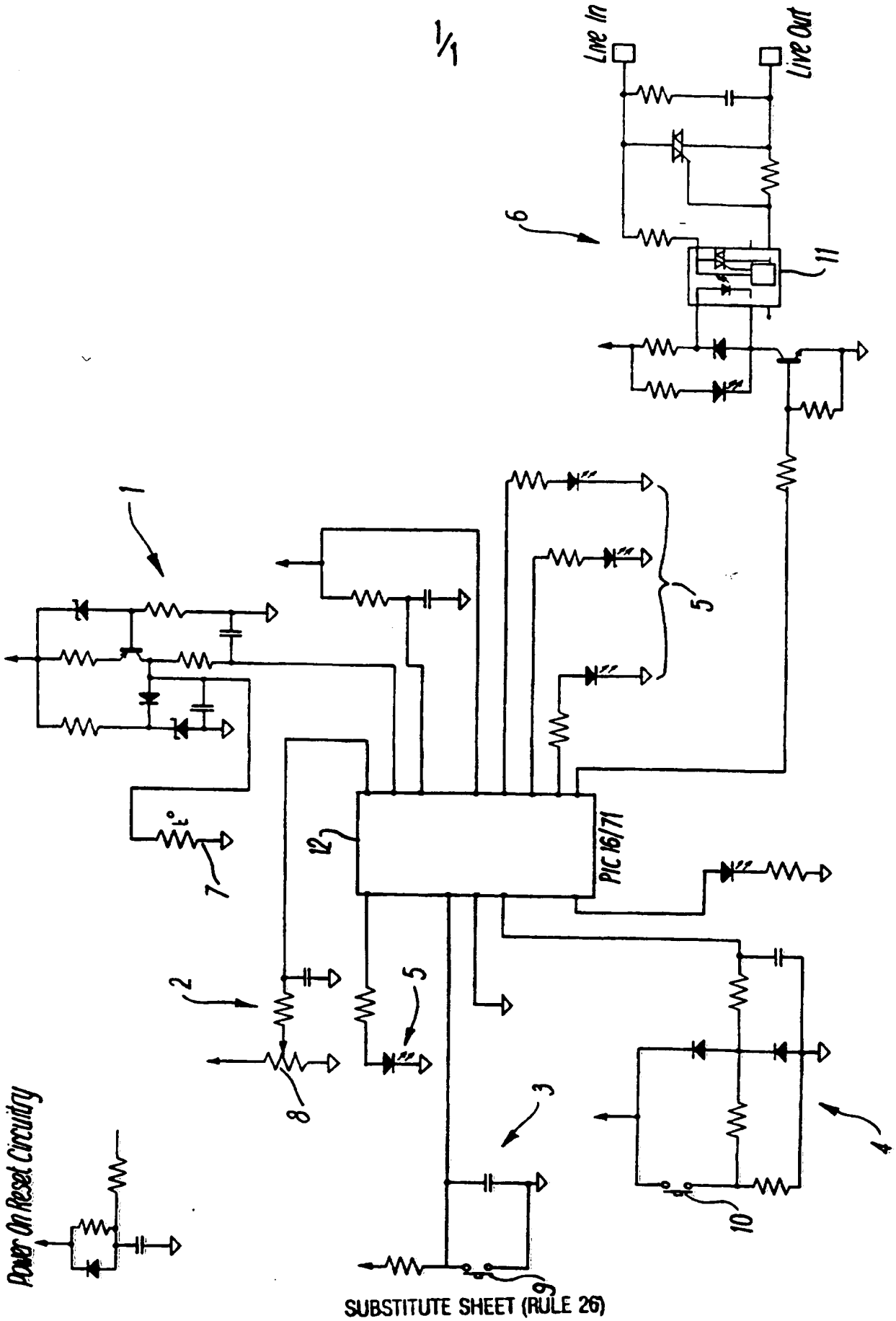
6. A system according to any one of claims 1 to 5 further including a reflected radiation sensor.

7. A system according to any one of claims 1 to 6 wherein the control

device also monitors time elapse.

8. A system according to any one of claims 1 to 7 when used with water heating equipment.

9. A system according to any one of claims 1 to 7 when used with cooking equipment.



INTERNATIONAL SEARCH REPORT

Intern. ..al Application No
PCT/IB 97/00779

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G05D23/19

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 2 073 455 A (APPLIANCE CONTROL SYST PTY) 14 October 1981 see the whole document ---	1-4 6
Y	US 4 675 826 A (GENTRY CHARLES B ET AL) 23 June 1987 see the whole document ---	6
X	US 4 473 183 A (KENSINGER ROBERT A ET AL) 25 September 1984 see the whole document ---	1
X	EP 0 138 171 A (GAINSBOROUGH ELECTRICAL) 24 April 1985 see page 6, line 28 - page 10, line 34 --- -/--	1,2,4,5, 8

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
25 September 1997	03.10.97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	**Authorized officer** Kelperis, K

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern. nal Application No
PCT/IB 97/00779

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 897 527 A (CRIPPS ALAN H ET AL) 30 January 1990 see claim 1 see the whole document	1,4
X	US 5 039 535 A (LANG HOWARD A ET AL) 13 August 1991 see column 9, line 5 - column 11, line 34	1,7
X	EP 0 124 469 A (COSDEN TECHNOLOGY) 7 November 1984 see the whole document	1-3
X	EP 0 119 580 A (EUROP EQUIP MENAGER) 26 September 1984 see the whole document	1,9
A	GB 2 207 261 A (SOUTH OF SCOTLAND ELECTRICITY) 25 January 1989 see the whole document	1,2,4

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. ional Application No
PCT/IB 97/00779

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2073455 A	14-10-81	DE 3113608 A	01-04-82
		JP 56155410 A	01-12-81
US 4675826 A	23-06-87	NONE	
US 4473183 A	25-09-84	NONE	
EP 0138171 A	24-04-85	GB 2148467 A	30-05-85
		GB 2184526 A,B	24-06-87
		US 4638147 A	20-01-87
US 4897527 A	30-01-90	AU 584039 B	11-05-89
		AU 5866686 A	04-12-86
		CA 1267676 A	10-04-90
		DK 7887 A	08-01-87
		EP 0222808 A	27-05-87
		WO 8606767 A	20-11-86
		GB 2175105 A,B	19-11-86
US 5039535 A	13-08-91	NONE	
EP 0124469 A	07-11-84	AU 2709684 A	25-10-84
		JP 60035488 A	23-02-85
		US 4613746 A	23-09-86
EP 0119580 A	26-09-84	FR 2542885 A	21-09-84
		DE 3472595 A	11-08-88
GB 2207261 A	25-01-89	NONE	